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ECHINODERMS FROM THE ISLANDS OF NIUAFOOU AND NUKUALOFA, TONGA ARCHIPELAGO, WITH THE DESCRIPTION OF A NEW GENUS AND TWO NEW SPECIES

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ECHINODERMS FROM THE ISLANDS OF NIUAFOOU AND NUKUALOFA, TONGA ARCHIPELAGO, WITH THE DESCRIPTION OF A NEW GENUS AND TWO NEW SPECIES

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While attached to the United States Naval Eclipse Expedition to the island of Niuafoou, 1930, Lieut. Henry C. Kellers (M. C.), United States Navy, made an extensive collection of the local echinoderms.

Niuafoou, or Tin Can Island, is one of the islands in the Tonga Archipelago, and is situated between Samoa and Fiji in latitude 15° 33′ 52″ S., longitude 175° 37′ 46″ W. It is a volcanic island subject to more or less frequent eruptions, the last of which took place on July 25, 1929.

Lieutenant Kellers tells me that, except for a distance of about 3½ miles, Niuafoou is practically surrounded by lava benches backed by basaltic cliffs from 70 to 100 feet in height. These benches are now covered as a result of the eruption of 1929, although in places one can see outcroppings of the old lava. They extend from 100 to 200 yards into the sea. On the outer edge they have an almost precipitous drop to the 20-fathom line, which runs out for practically a mile, where the sea floor sinks to the abysses.

Some of the benches are awash all the time and are mostly entirely covered at high tide. At low water tide pools of all sizes are found, and in these tide pools most of the collecting was done.

Lieutenant Kellers's collection includes a few specimens that were brought to him by natives from Nukualofa, the seat of government of the Tonga Group, a couple of hundred miles to the southwest of Niuafoou.

The echinoderms found at Niuafoou were species that would be expected to occur on an island situated in this general region, with a single remarkable exception. This exception is an entirely new genus of echinoids of the family Echinometridae, represented by two species, which is related to *Podophora* and also to *Heterocentrotus*.

It seems to represent *Podophora* here much as *Colobocentrotus*, also with two species, represents it in the Bonin Islands. The genus *Podophora* itself also includes two species, one of which, *P. atrata*, ranges from Zanzibar and Mauritius to the Hawaiian Islands but is very local in its occurrence and has been reported only from volcanic regions; while the other, *P. pedifera*, is definitely known only from the Tuamotus, although it has been reported from the western coast of South America and from the West Indies.

In addition to the sea urchins and sea stars listed in the following pages, the collection includes a number of ophiurans and holothurians.

I am greatly indebted to Dr. Hubert Lyman Clark, of the Museum of Comparative Zoölogy at Cambridge, Mass., for his kindness in examining for me and commenting upon the type specimen of *Zenocentrotus paradoxus*, and for his further kindness in revising the manuscript of the present paper.

Class ECHINOIDEA

Family CENTRECHINIDAE

CENTRECHINUS SETOSUS (Leske)

One small specimen.

ECHINOTHRIX DIADEMA (Linnaeus)

One small specimen.

Family STOMOPNEUSTIDAE

STOMOPNEUSTES VARIOLARIS (Lamarck)

Six specimens, all but one of which are small.

Very small specimens much resemble similarly small individuals of *Echinometra oblonga*. They may easily be distinguished, however, by the milled ring at the base of the primary spines, which is only slightly developed and not sharply differentiated from the spine itself, is very fine, and is of the same color as the spine. In small examples of *Echinometra oblonga* the milled ring is strongly developed and stands out abruptly from the spine itself, is coarse, and is brilliant white, or pinkish or grayish white, in sharp contrast to the deep olive or blackish color of the spine.

The United States National Museum possesses a fine series of 83 specimens of this species collected by Owen Bryant at Pelaboean Ratoe, Wynkoops Bay, western Java.

Family ECHINIDAE

TRIPNEUSTES GRATILLA (Linnaeus)

Two specimens, one with dark and the other with whitish spines.

Family ECHINOMETRIDAE

PARASALENIA GRATIOSA A. Agassiz

Nukualofa Island. Two specimens; the larger is parasitized by a small gastropod.

The larger specimen measures 33 mm. in the longer axis and 26 mm. in the shorter. The longest spines on the longer axis are 23 mm. in length, and the longest spines on the shorter axis measure 19 mm.

The periproct is largely covered by five large plates. Of these, two are situated on the inner border of genital 1, one is on genital 2, one occupies the whole inner edge of genital 3 and about two-thirds of that of genital 4, and one occupies one-third of the inner border of genital 4 and nearly all that of genital 5. These plates are short with broadly rounded tips, and the center of the periproct is covered with eight small subequal plates.

Genital 3, though long, is very narrow, and its inner border is only about half as long as that of genitals 2 and 4. Genital 1 is short but broad, and genital 5 is the smallest, triangular, with its inner border about twice as long as that of the elongate rhombic genital 3.

Genitals 4, 5, and 1 each bear a single cylindrical or more or less club-shaped spine 2 mm. long situated near the inner edge. Genital 2 bears two spines, one diagonally behind and close to the other. Genital 3 bears two spines, one in the middle of the plate and one near the inner border. In addition to these spines, the genitals bear a few pedicellariae, some of which have jointed stalks.

Oculars II and V are insert, and ocular I is very nearly so, but oculars III and IV are very widely excluded from the periproct. Oculars II, III, and IV each bear a spine similar to the spines borne by the genitals.

Most of the spines remain cylindrical from the base to the end of the proximal third or half, from that point tapering regularly to the tip, but some taper regularly from the base, and some increase slightly in diameter as far as the end of the proximal third or half.

The test is deep black. The spines are dark olive-brown, most of them with the tips polished. The spines at and below the ambitus are somewhat lighter with longer and more prominent polished tips. The milled ring is pure white and very conspicuous.

The smaller specimen measures 21 mm. in the longer axis and 16 mm. in the shorter. The longest spines in the longer axis are 18 mm. in length, and the longest spines on the shorter axis measure 13 mm.

The periproct is completely covered by four plates. Two of these, one occupying one corner of genital 2, the whole inner edge of genital 3, and two-thirds of the inner edge of genital 4, and the other occupying one-third of the inner edge of genital 4 and the entire inner edge of genital 5, are subequal and larger than the two opposite.

The genitals are more nearly of the same size than in the other specimen. Genital 2 is the largest, followed by genital 4; genital 3 is narrower than 2 or 4 but longer; and genital 5 is longer than genital 1. The inner border of genital 3 adjoining the periproct is about half as long as the inner border of the other genitals. Genital 2 bears a cylindrical spine near the inner border, and genitals 3 and 4 have a prominent tubercle in this position but no spine; genitals 1 and 5 bear neither spines nor tubercles.

All the oculars are exsert, ocular II only slightly so, oculars I and V about twice as much so as ocular II, and oculars III and IV three or four times as much so as oculars I and V. Oculars I and III bear each a cylindrical spine, and all the oculars bear several pedicellariae.

In color this specimen resembles the other, but the spines are slightly lighter, a very few of the spines on the oral surface showing light tips with one or two very obscure subapical dark bands.

ECHINOMETRA MATHAEI (de Blainville)

Four hundred and thirty-eight specimens, all but 22 of which are more or less strongly flattened immature and young of various sizes, and are referable to *E. picta* as described by A. Agassiz and H. L. Clark.

In their final account of *E. picta* these authors said that the more the specimens on which that form is based are studied, the more doubtful it seems whether it is really distinct from *E. mathaei*. They note that in the specimens regarded as *picta* the test is distinctly flattened and is wider than usual, and the spines seem to be less crowded and are somewhat more slender than in *mathaei*, and are much less numerous on the abactinal system. The latter is distinctly larger than it is in *mathaei*, its diameter sometimes nearly equaling one-third of the test length. There is seldom more than one secondary tubercle on each genital plate. The color is dark brown for the test and light fawn color for the spines. Agassiz and Clark say that these specimens intergrade more or less com-

pletely with *mathaei* in each one of the characters, but are usually easily distinguished by the combination of all five. They remarked that such specimens occur only in material from the Hawaiian, Society, and Philippine Islands.

The specimens from Niuafoou are very variable in every feature, but those that are referable to *picta* seem simply to represent the younger or immature stages of the large ones, which are undoubtedly referable to *mathaei*.

In color the test is always dark, usually a more or less deep reddish brown, though sometimes quite black. The spines may be light olive-gray to deep olive, with long or short white or pinkish tips usually preceded by a broad and indefinite very dark band; or fawn color, uniform or with lighter or darker tips; or olive with fawn-colored tips; or olive becoming gradually darker at the tips; or whitish faintly tinged with olive or with fawn color. The milled ring is almost always pure white, but is occasionally slightly tinged with fawn color or pink.

In some specimens, apparently from quiet water, the spines are very slender and much elongated.

ECHINOMETRA OBLONGA (de Blainville)

PLATE 5, FIGURE 3; PLATE 7, FIGURE 3

One hundred and seventy-eight specimens, most of which are young of various sizes.

Young individuals of this species (pl. 5, fig. 3; pl. 7, fig. 3) are much flattened and broadened, the longer diameter being often but slightly in excess of the shorter, and the spines are slender and relatively long, and occasionally elongated. This gives them a considerable superficial resemblance to similarly small examples of *Stomopneustes variolaris*.

The specimens are all very dark in color, purplish black or very dark olive. The milled ring at the base of the primary spines is usually pure white, sometimes white tinged with purplish, pinkish, or olive.

A specimen from Puako Bay, Hawaii, recorded by A. Agassiz and H. L. Clark as *Echinometra picta* (U.S.N.M. No. 32813) seems to me to be a young example of this species.

ZENOCENTROTUS, new genus

Diagnosis.—A genus of Echinometridae in which the longer axis, which only slightly exceeds the shorter, passes through interambulacrum 4a and ambulacrum IIa; the ambulacral plates consist of 9 to 11 elements; the periproct is studded with numerous small plates;

the primary spines are circular, subtriangular, or oval in cross section, tapering, with parallel sides, or with slightly divergent sides, becoming broad and much flattened below the ambitus, much longer at the ambitus than elsewhere; the miliary spines are short, rather stout, mostly tapering and abruptly truncated at the tip, the smaller slender and club shaped; and the primary tubercles are of moderate size, one to each interambulacral plate above the ambitus, two, and later two larger and one smaller at and below the ambitus.

Genotype.—*Zenocentrotus kellersi*, new species.

Range.—Only known from Niuafoou Island, between Samoa and Fiji.

Included species.—*Zenocentrotus kellersi* and *Z. paradoxus.*

Remarks.—Except for the position of the longer axis, the test of *Zenocentrotus*, especially of *Z. paradoxus*, is very similar to that of *Echinometra vanbrunti*, in which the test is much flattened, the longer axis is often only slightly longer than the shorter, and there are numerous pore pairs—usually 7 or 8. In a specimen of *Echinometra vanbrunti* of approximately the same size as the type specimen of *Zenocentrotus kellersi*, there are 15 interambulacral and 20 ambulacral plates in each column as in that species.

The genus *Zenocentrotus*, however, appears to be most closely related to *Heterocentrotus* with which it agrees in the main features of the test, particularly the number and relative size of the primary tubercles, and the shape and structure of the poriferous areas on the oral surface. The test is, however, much more nearly circular and much more depressed than in *Heterocentrotus.* Though much more slender, the primary spines are of the same general character as those of *Heterocentrotus trigonarius*, and the young specimens of this species have a very considerable general resemblance to the species of *Zenocentrotus*, some to *Z. kellersi* (compare pl. 8, fig. 1, and pl. 3, fig. 1), and others to *Z. paradoxus* (compare pl. 8, fig. 2, and pl. 6, fig. 2). In a specimen of *Heterocentrotus trigonarius* with the test 80 mm. in the longer axis, there are 10 or 11 interambulacral and 14 to 15 ambulacral plates in each column, the plates being therefore considerably fewer than in *Zenocentrotus.*

The longer axis in *Heterocentrotus* passes through ambulacrum IVb and interambulacrum 1b, while in *Podophora* and in *Colobocentrotus* it passes through interambulacrum 4a and ambulacrum IIa as in *Zenocentrotus.* As in *Echinometra*, the test in *Podophora* and in *Colobocentrotus* varies from subcircular or rounded pentagonal to elliptical, and from much flattened to rather strongly arched. The broad poriferous zones, especially the greatly broadened poriferous areas on the oral surface, the very numerous tubercles on the interambulacral plates, and the more or less marked concavity of the

oral surface of the test along the longer axis, readily separate *Podophora* and *Colobocentrotus* from *Zenocentrotus*. The teeth of *Zenocentrotus*, it may be noticed, with their strongly beveled sides and broad flat upper surface bordered with fine rounded ridges, resemble the teeth of *Podophora* more closely than they do the teeth of the other genera.

The tube-feet resemble those of related genera, but the sucking disk is divided into almost invariably 5 (occasionally 6 and rarely 4) sectors, instead of into 4 as in *Podophora* and *Colobocentrotus* or 5 or 6 in *Heterocentrotus*.

KEY TO THE SPECIES OF THE GENUS ZENOCENTROTUS

a^1. Poriferous areas below much broadened, in the widest portion three-fourths the width of the adjacent portion of the interambulacral area, with the outer border strongly convex; tubercles on the interambulacral plates above the ambitus with their bases separated by less than the diameter of the tubercles; primary spines at ambitus long and mostly somewhat tapering, the spines gradually decreasing in length toward the periproct ..... **kellersi.**

a^2. Poriferous areas below not greatly broadened, in the widest portion not more than half the width of the adjacent portion of the interambulacral area, with the outer border gently convex; tubercles on the interambulacral plates above the ambitus with their bases separated by much more than the diameter of the tubercles; spines at the ambitus less elongated and mostly increasing slightly in width distally ..... **paradoxus.**

ZENOCENTROTUS KELLERSI, new species

PLATES 1–3; PLATE 4, FIGURE 1; PLATE 5, FIGURE 1; PLATE 6, FIGURE 3

Description of the type specimen.—The longer diameter of the test is 55 mm., and the shorter diameter is 47.5 mm.; the height is 19 mm.

There are 15 or 16 interambulacral and 20 ambulacral plates in each column.

The periproct (pl. 1) is irregularly oval, 4 by 3 mm.; it bears numerous small plates, which decrease in size inwardly; a very few of the larger plates bear tubercles. The madreporic plate is more than half again as large as the other genitals, which are subequal in size. It is situated in the middle half of one of the sides of the periproct delimited by the longer axis. It bears about 14 very minute tubercles, which are arranged roughly in two irregular transverse rows across the middle. The other genitals are subequal in size. Each bears 7 to 9 small tubercles, of which 2, situated on the inner margin, are much larger than the others.

All the oculars are exsert, II and III widely so, IV rather less widely, I still less widely, and V barely exsert. The oculars are very small, chevron-shaped, each with five very small tubercles.

Near the oculogenital ring each interambulacral plate bears a prominent central tubercle and a few small peripheral tubercles. These last on the third or fourth plate beyond the genital form a complete row and vary somewhat in size, those at the angles of the plates being the largest. Just above the ambitus those near the outer edge of the plate rapidly increase in size, and at the ambitus others beyond these also increase in size so that when viewed from above the inner two-thirds or half of the interambulacral areas is seen to bear two rows of large tubercles, while the outer third has four rows; and at and just below the ambitus there is a short row of somewhat smaller tubercles beyond each of the outer rows. On the actinal surface of the test these six rows rapidly converge, as a result of the broadening of the poriferous areas, and the tubercles become smaller. Two-thirds of the distance from the ambitus to the peristome the intermediate rows on each half of the interambulacra come to an end, and from that point the two central rows, and at some distance from them the two outermost rows, continue parallel to the peristome.

The ambulacral plates each bear a prominent tubercle, which slowly increases in size from the oculogenital ring to the ambitus; on the oral side of the test these tubercles rapidly decrease in size, and the two lines of tubercles converge; slightly more than halfway between the ambitus and the peristome the now very small tubercles form two parallel rows close together and run to the peristome.

There are 8 to 11 (usually 9 or 10) pore pairs in an arc both at the ambitus and near the oculars.

The oral surface of the test (pl. 2) is flat, and is only very slightly, if at all, concave in the longer axis. The peristomal area is pentagonal with double angles. The radius to the point of an angle (on the ambulacral-interambulacral border) is 11.5 mm., and the radius to the deepest (inner) portion of a poriferous area is 10 mm.

On the oral surface the poriferous areas gradually and regularly broaden to a maximum width of 5.5 mm. two-thirds of the distance from the ambitus to the peristome. From that point the outer border curves broadly downward and inward, but the inner border curves only very slightly. At their widest point the poriferous areas are about three-fourths as broad as the interambulacral areas separating them.

At the ambitus the primary spines are from 20 to 25 mm. long, the lower more or less strongly flattened, especially on the lower side. Though the lower side is slightly and evenly convex, the

upper side is less evenly rounded, being highest in the center, the cross section being a more or less low triangle with broadly rounded angles, the upper obtuse angle becoming less and less marked distally. The spines are about 2.5 mm. broad with parallel sides and an abruptly truncated tip. Just below the ambitus the spines are somewhat shorter and more flattened, and broaden slowly from the base to the distal half or two-thirds. On the oral surface they are abruptly shorter, and they rapidly decrease in size adorally, becoming at the same time much more slender.

Above the ambitus the primary spines decrease in length and become less flattened and more pointed, tapering evenly from the base to the somewhat blunted tip and being more or less regularly rounded in cross section. The spines on the third interambulacral plates below the apical disk are 13 to 15 mm. long.

Interspersed with these large spines are great numbers of much smaller spines from 3 to 5 mm. in length. These are mostly, especially along the poriferous zones, club shaped, slowly increasing in diameter to an abruptly truncated tip. A few of the larger ones have parallel sides, and some taper to a blunt tip.

The primordial ambulacral plates are rounded wedge shaped, the two of each pair with their larger ends together, forming a closed ring about the mouth. They are studded with tubercles and bear small blunt spines and numerous pedicellariae. Frequently very small nonambulacral plates are intercalated between these pairs of ambulacrals.

The peristomal membrane is thickly set with very numerous very small and greatly elongated plates arranged concentrically, and it also bears a few widely scattered small rounded plates each with a median tubercle and spine and a thickened rim.

The teeth are much flattened and very thin, as in *Podophora*, with a narrow elevated rim bordering the flat upper surface on each side. In section the teeth are flattened trapezoidal.

The color is dull olive-brown with a tinge of purplish, the long spines at the ambitus lighter below and outwardly more or less strongly tinged with violet.

Type.—U.S.N.M. No. E. 2810, collected at Niuafoou by Lieut. H. C. Kellers on October 6, 1930.

Six additional specimens were collected on October 5 and 6, 1930.

Notes.—In the largest specimen (pl. 4, fig. 1; pl. 5, fig. 1) the longer diameter of the test is 60 mm., and the shorter diameter is 55 mm.; the height of the test is 25 mm. The longest spines at the ambitus are 30 mm. and the spines near the apical disk are 15 mm. long. The color is dull olive, the longest spines tinged with violet toward the tip; the spines at and below the ambitus have violet tips beneath.

In the smallest specimen (pl. 6, fig. 3) the diameter of the test is 25.5 mm. The longest spines at the ambitus are 20 mm. long and the spines nearest the periproct are 12 mm. long. The color is dull olive.

ZENOCENTROTUS PARADOXUS, new species

PLATE 5, FIGURE 2; PLATE 6, FIGURES 1, 2; PLATE 7, FIGURES 1, 2

Description of the type specimen.—The longer diameter of the test is 37 mm., and the shorter diameter is 33 mm.; the height is 13.5 mm.

There are 13 or 14 interambulacral and 16 ambulacral plates in each column.

The large spines at the ambitus (pl. 5, fig. 2; pl. 6, figs. 1, 2) are flatter and more broadened than in *Z. kellersi*, all of them increasing slightly in width distally or having parallel sides; none taper distally. On the apical surface the spines very rapidly decrease in size above the ambitus, almost immediately becoming short, and mostly very short, the longest not more than 7 or 8 mm. in length. About the peristome (pl. 7, fig. 2) there is in each interambulacral area a group of usually 4 long, slender, narrowly spatulate spines 4–5 mm. long which stand out rather conspicuously because of their length from the other spines on the oral surface. In *Z. kellersi* (pl. 4, fig. 1) the spines in this position are not noticeably different from those behind them.

The oculars (pl. 6, fig. 1) are larger than in the type specimen of *Z. kellersi*, with I and V more fully exsert; each bears from 1 to 3, usually 3, very small tubercles.

The tubercles on the interambulacral and ambulacral plates are relatively smaller than in *Z. kellersi*, and are more widely separated.

There are 10 or 11, usually 11, pore pairs in an arc.

On the oral surface (pl. 7, fig. 1) the poriferous zones are less broadened, being where they are widest about half as broad as the interambulacral areas separating them. Their outer margin is much less strongly curved than in *Z. kellersi*, and the tubercles in the two ambulacral rows between the poriferous zones are smaller at the ambitus and decrease more gradually in size.

Type.—U.S.N.M. No. E. 2813, collected at Niuafoou by Lieut. H. C. Kellers on September 20, 1930.

Thirteen additional specimens were collected on September 19 and 20 and on October 6, 1930.

HETEROCENTROTUS TRIGONARIUS (Lamarck)

PLATE 4, FIGURE 2; PLATE 8

Twenty-seven specimens. In the largest specimen the longer diameter of the test is 55 mm., and the longest spines are 75 mm. long.

In the smallest the longer diameter of the test is 25 mm., and the longest spines are 20 mm. long.

These specimens, most of which are small, show very great diversity. In the largest (pl. 8, fig. 1) the primary spines near the center of the apical surface are very stout at the base, regularly tapering and conical, and up to 57 mm. long. Toward the ambitus the primary spines gradually increase in length, reaching a maximum of 75 mm., and at the same time gradually become rounded trigonal with somewhat blunted tips. The secondary spines for the most part are stout and sharp pointed, but those on the apical disk are very short and abruptly truncated.

In three other specimens the primary spines are rather slender, tapering, and trigonal. In one there are a few short and abruptly truncated spines on and about the periproct and in the upper portions of the ambulacral areas; in another short and irregularly truncated spines are rather numerous on and about the apical system; while in the third such spines are very numerous.

In all the other specimens (*cf.* pl. 4, fig. 2; pl. 8, fig. 2) the primary spines are thickened, more or less club shaped, with abruptly rounded tips. In some the large primaries of the ambulacral areas run up almost to the oculars, while in others a large portion of the ambulacral areas on the apical surface is covered simply with short abruptly truncated spines, which in extreme cases may extend nearly to the ambitus as in *H. mammillatus*.

Class ASTEROIDEA

Family ARCHASTERIDAE

ARCHASTER TYPICUS Müller and Troschel

Nukualofa Island. One specimen.

LINCKIA LAEVIGATA (Linnaeus)

Seventeen large specimens.

LINCKIA MULTIFORA (Lamarck)

Nukualofa Island. Two small specimens.

EXPLANATION OF PLATES

PLATE 1

Zenocentrotus kellersi, the type specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2810), apical view, ×2. Oral view of the same specimen shown in Plate 2.

PLATE 2

Zenocentrotus kellersi, the type specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2810), oral view, ×2. Apical view of the same specimen shown in Plate 1.

PLATE 3

FIGURE 1. *Zenocentrotus kellersi*, a medium-sized specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2970), apical view, natural size.

2. *Zenocentrotus kellersi*, the same specimen, oral view, natural size.

PLATE 4

FIGURE 1. *Zenocentrotus kellersi*, the largest specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2811), oral view, natural size. Apical view of the same specimen shown in Plate 5, Figure 1.

2. *Heterocentrotus trigonarius*, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2918), oral view, natural size. Apical view of the same specimen shown in Plate 8, Figure 2.

PLATE 5

FIGURE 1. *Zenocentrotus kellersi*, the largest specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2811), apical view, natural size. Oral view of the same specimen shown in Plate 4, Figure 1.

2. *Zenocentrotus paradoxus*, Niuafoou, September 20, 1930 (U.S.N.M. No. E. 2814), apical view, natural size. Oral view of the same specimen shown in Plate 7, Figure 2.

3. *Echinometra oblonga*, young, Niuafoou, September 13, 1930 (U.S.N.M. No. E. 2897), apical view, ×2. Oral view of the same specimen shown in Plate 7, Figure 3.

PLATE 6

FIGURE 1. *Zenocentrotus paradoxus*, the type specimen, Niuafoou, September 20, 1930 (U.S.N.M. No. E. 2813), apical view, ×2. Oral view of the same specimen shown in Plate 7, Figure 1.

2. *Zenocentrotus paradoxus*, Niuafoou, September 20, 1930 (U.S.N.M. No. E. 2814), apical view, natural size.

3. *Zenocentrotus kellersi*, the smallest specimen, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2970), apical view, ×2.

PLATE 7

FIGURE 1. *Zenocentrotus paradoxus*, the type specimen, Niuafoou, September 20, 1930 (U.S.N.M. No. E. 2813), oral view, ×2. Apical view of the same specimen shown in Plate 6, Figure 1.

2. *Zenocentrotus paradoxus*, Niuafoou, September 30, 1930 (U.S.N.M. No. E. 2814), oral view, natural size. Apical view of the same specimen shown in Plate 5, Figure 2.

3. *Echinometra oblonga*, Niuafoou, September 13, 1930 (U.S.N.M. No. E. 2897), oral view, ×2. Apical view of the same specimen shown in Plate 5, Figure 3.

PLATE 8

FIGURE 1. *Heterocentrotus trigonarius*, Niuafoou, August 31, 1930 (U.S.N.M. No. E. 2903), apical view, natural size.

2. *Heterocentrotus trigonarius*, Niuafoou, October 6, 1930 (U.S.N.M. No. E. 2918), apical view, natural size. Oral view of the same specimen shown in Plate 4, Figure 2.

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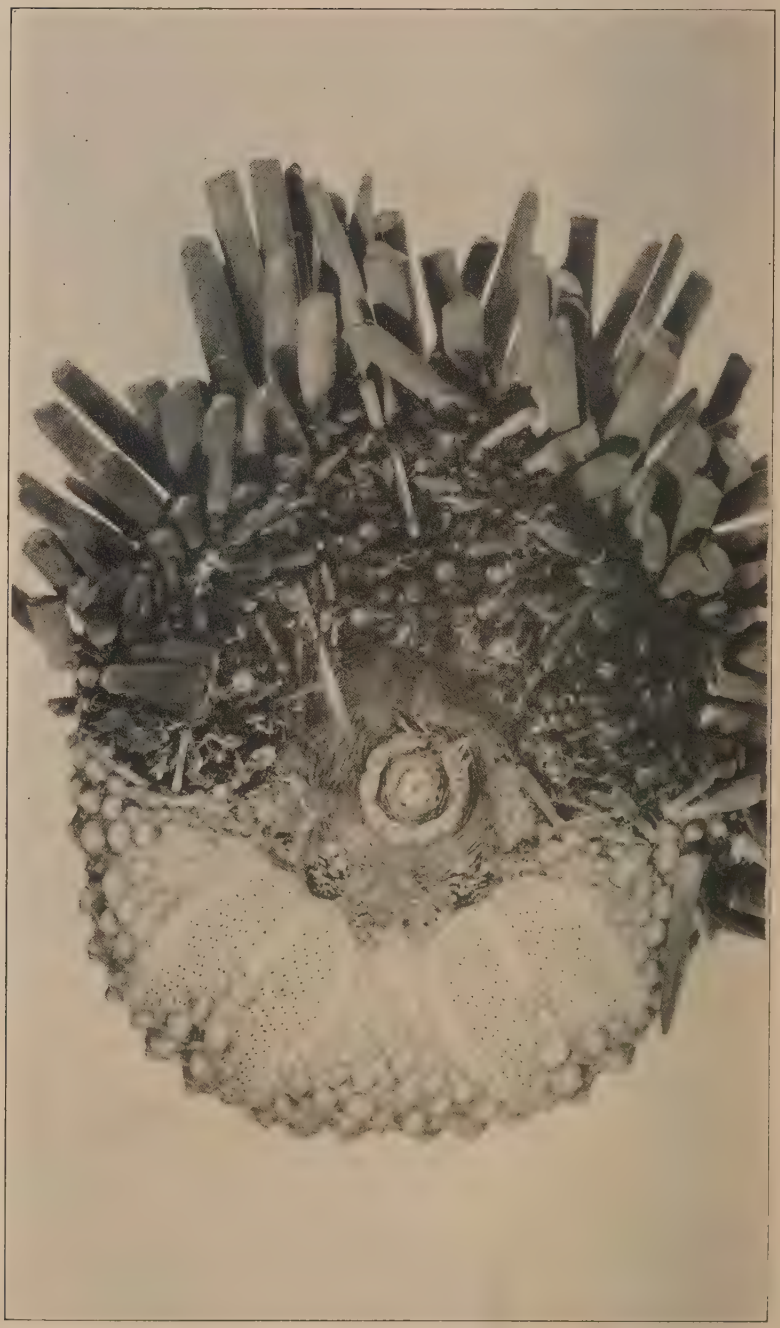
ZENOCENTROTUS KELLERSI

FOR EXPLANATION OF PLATE SEE PAGE 11.



ZENOCENTROTUS KELLERSI

FOR EXPLANATION OF PLATE SEE PAGE 11.

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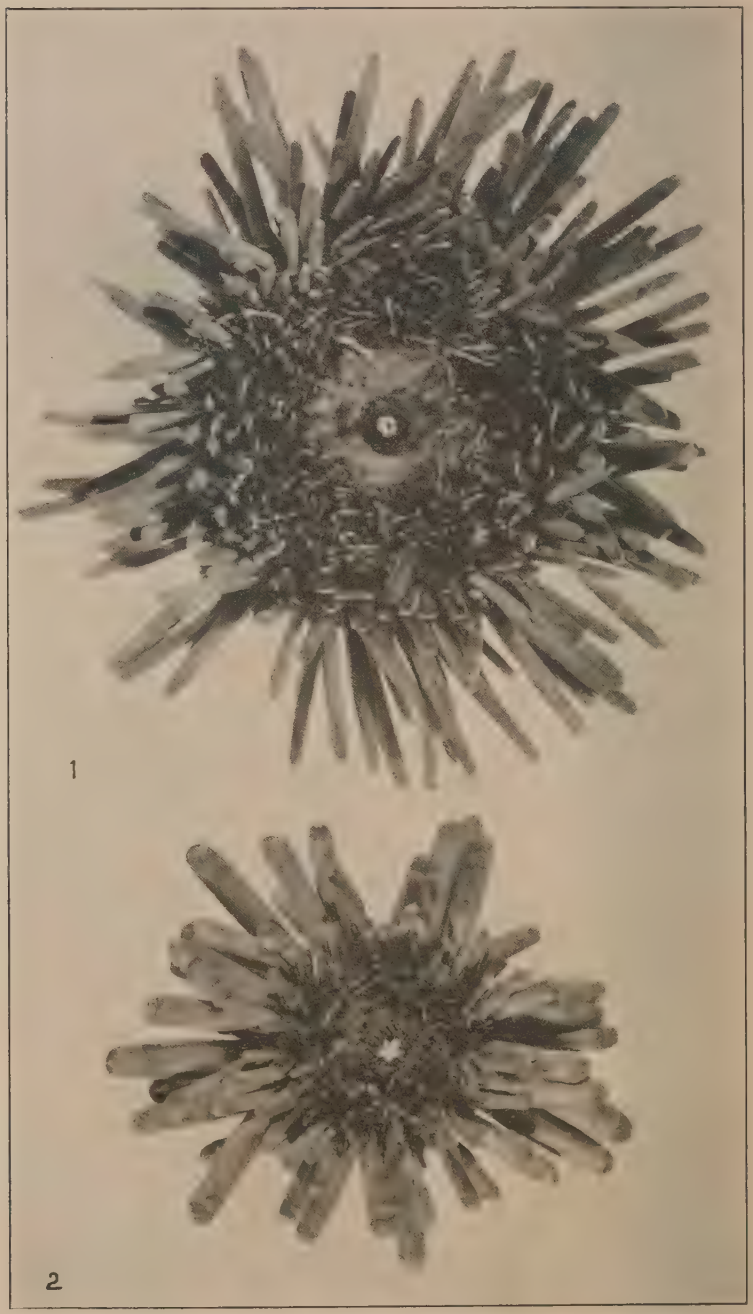
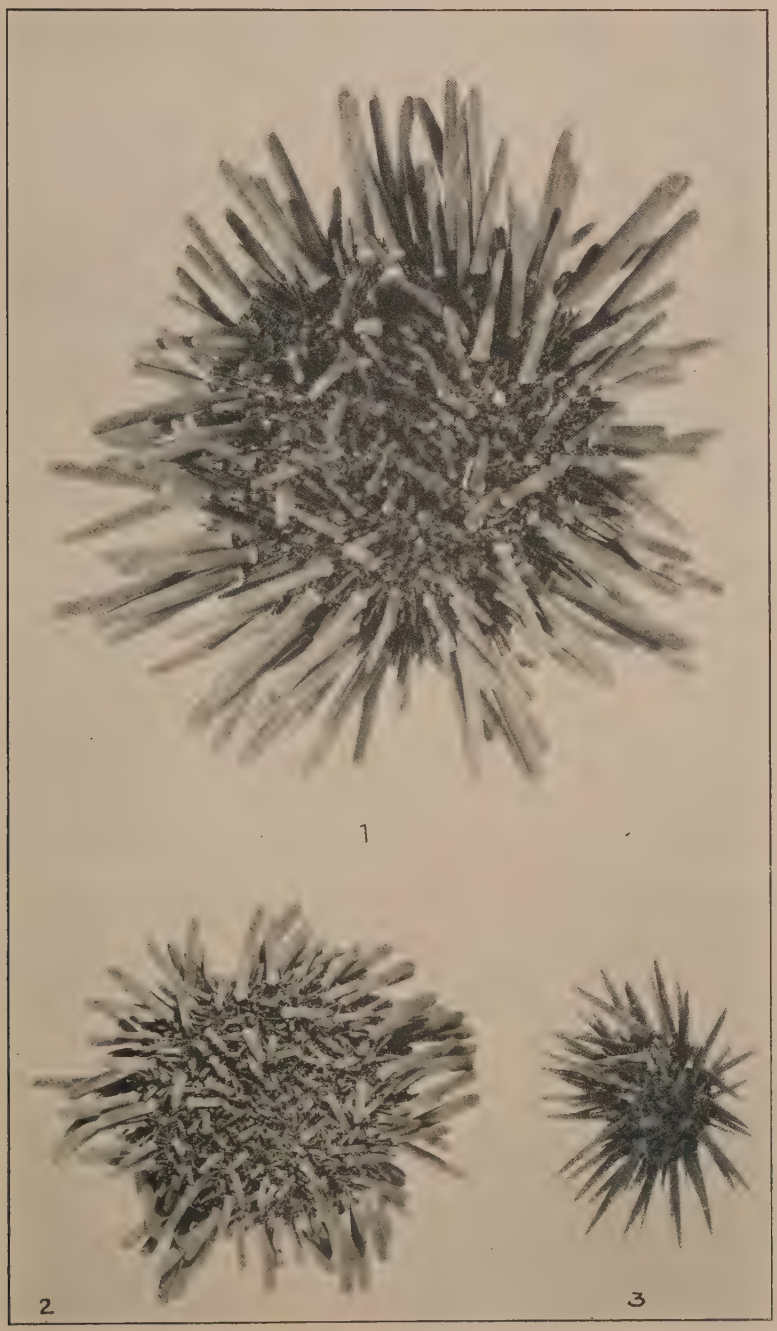
ZENOCENTROTUS KELLERSI

FOR EXPLANATION OF PLATE SEE PAGE 12.



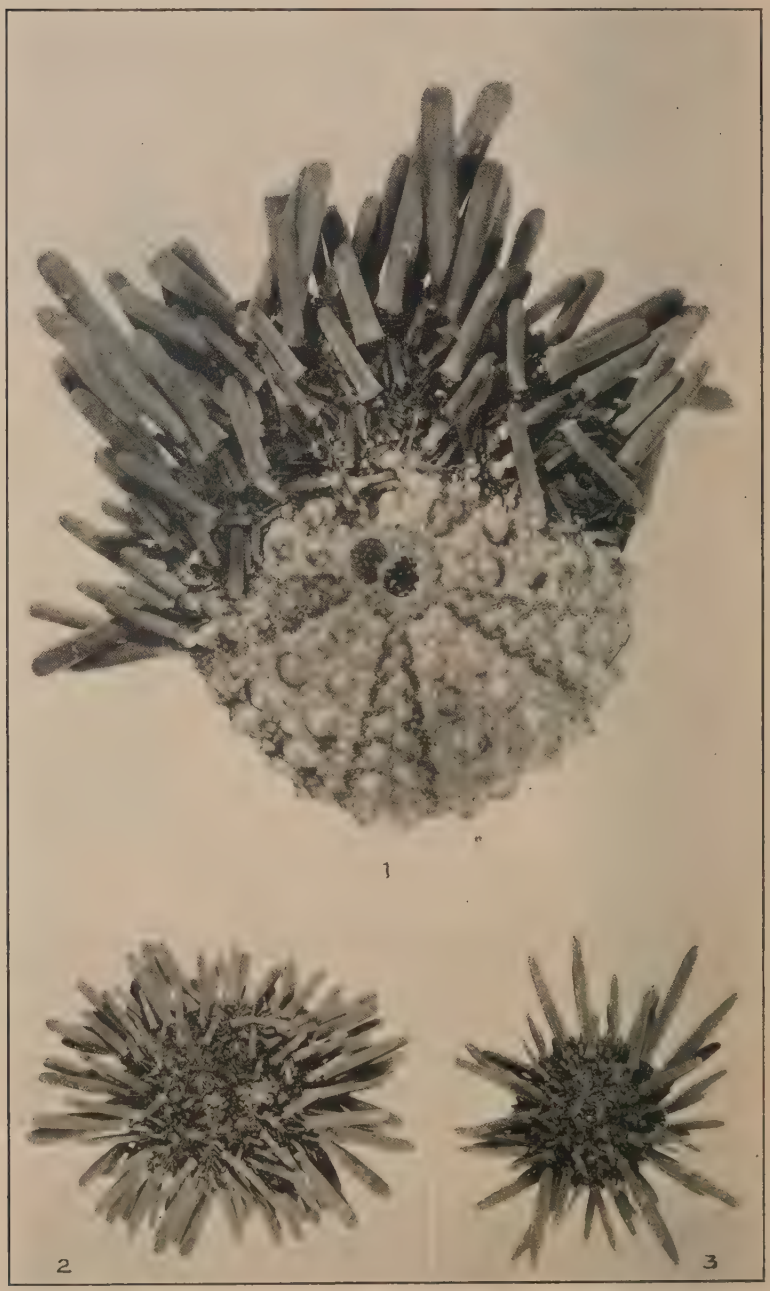
ZENOCENTROTUS KELLERSI AND HETEROCENTROTUS TRIGONARIUS

FOR EXPLANATION OF PLATE SEE PAGE 12.



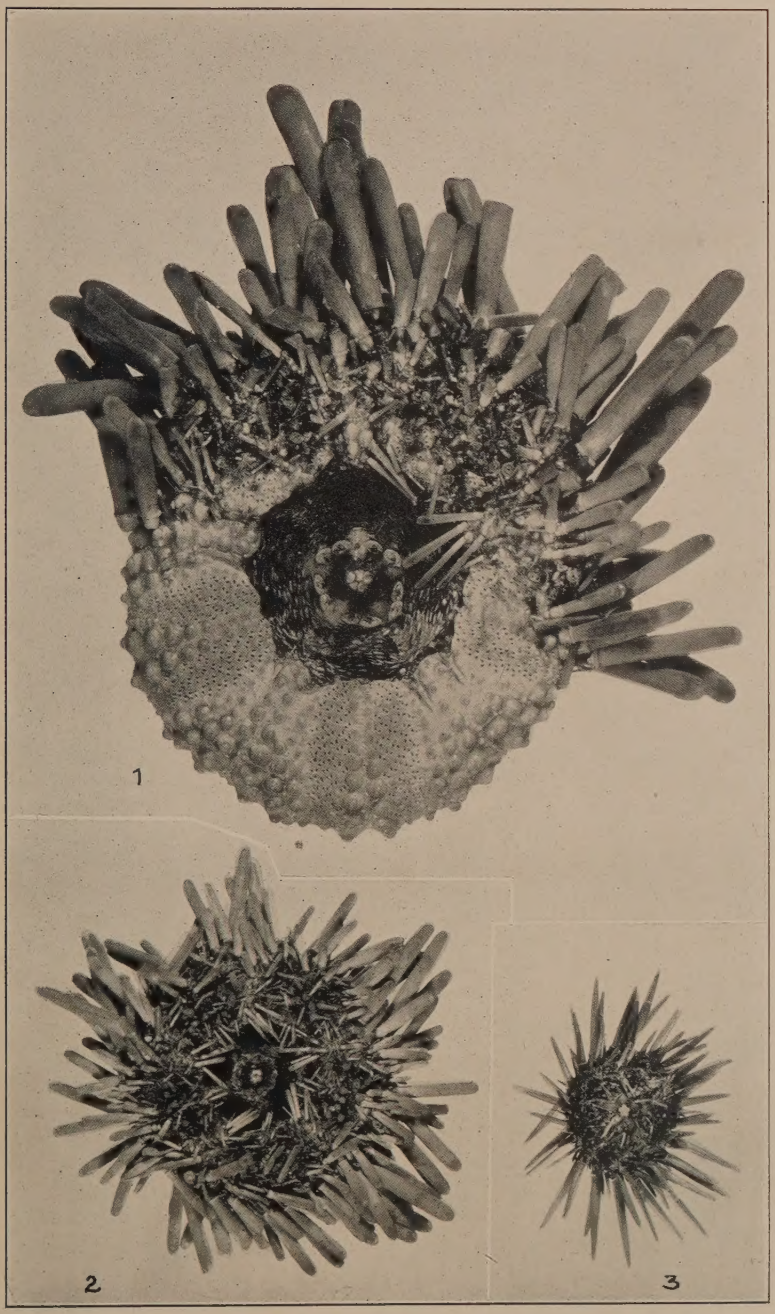
ZENOCENTROTUS KELLERSI, Z. PARADOXUS, AND ECHINOMETRA OBLONGA

FOR EXPLANATION OF PLATE SEE PAGE 12.



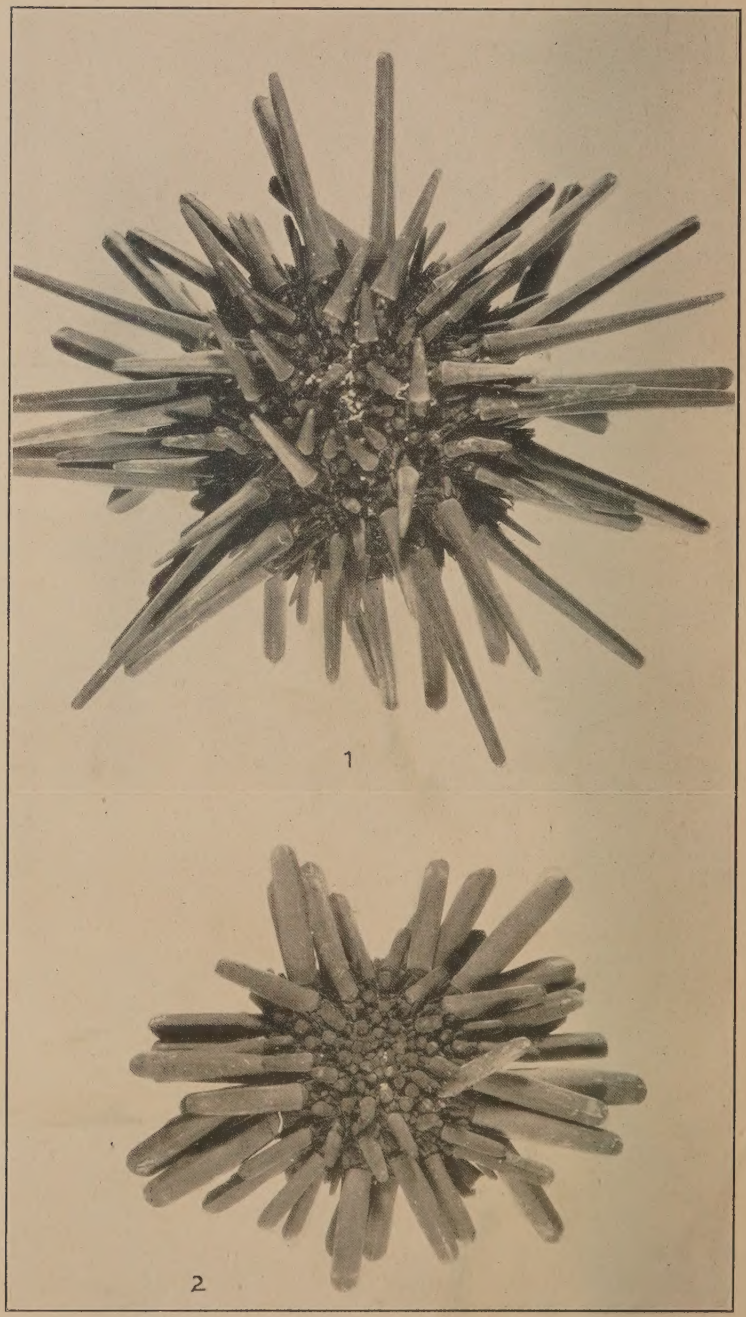
ZENOCENTROTUS PARADOXUS AND Z. KELLERSI

FOR EXPLANATION OF PLATE SEE PAGE 12.



ZENOCENTROTUS PARADOXUS AND ECHINOMETRA OBLONGA

FOR EXPLANATION OF PLATE SEE PAGE 12



HETEROCENTROTUS TRIGONARIUS

FOR EXPLANATION OF PLATE SEE PAGE 12.